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EXPERIMENTS WITH SALMONOIDS AND TURBINES.*

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During the progress of the investigations by the Irish Inland Fisheries' Commission of 1899 and 1900 many statements were brought forward as to the injuries to Salmonoids caused by the turbines so frequently used in Irish mills—indeed, complaints of this kind had been brought before the authorities more than ten years previously, and Sir Thomas Brady had been deputed to investigate the subject in 1892. As, however, the matter seemed to be important, and as the experiments carried out by Sir Thomas were few in number, it was resolved again to make careful inquiries. Accordingly the writer carried out experiments both in Scotland and Ireland in 1900, a record of which, by the kind permission of the Department in Dublin Castle, and Lord Justice Walker, Bart., Chairman of the Irish Inland Fisheries Commission, is given in the following pages.

Before detailing the work of 1900, it is well to premise by giving a brief account of the inquiry by Sir Thomas Brady, late Inspector of Fisheries in Ireland. In May, 1892, experiments with Smolts and turbines were carried out by Sir Thomas, under the authority of the Select Committee on the Salmon Fisheries (Ireland) Acts Amendment Bill. He used a small-meshed net

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in the form of an eel or coghill net for capturing the fishes after they had passed through the turbines and had reached the tail-race. This net was twelve feet wide, and tapered to a pocket or narrow, kept open by hoops, and fishing into a floating box covered with perforated zinc. The ground-rope of the net was heavily weighted with lead. In all five experiments were performed, *viz.*: (1) at Devil's Mills (Mr. Shackleton's), Lucan; (2) Messrs. Hill's Mill at the same place; (3) at the Salmon-Leap (Mr. Wookey's), on the same river; (4 and 5) at Coagh Mills (Messrs. Duff's).

In the first experiment the turbine was an Alcott, sixty-six inches in diameter, with seventy revolutions, and a fall of seven feet. Ten Smolts were put in the turbine-pit. In ten minutes the net was lifted, and no trace of the fishes observed. Four dead Smolts were then placed in the pit with the turbine in full operation. In ten minutes they floated down the stream and were secured with a landing-net. "Two were uninjured in appearance; one was broken across the back." Two other dead Smolts (specially marked) were placed in the pit, and they were secured in the tail-race, apparently uninjured. In all probability the ten Smolts placed in the pit by Sir Thomas Brady resisted the efforts of the turbine to engulf them, or, if they passed through, kept to the stream above the net, or passed by the side or beneath. A sickly, dying, or dead fish would soon have appeared in the tail-race or the net.

In the second experiment a Leffell turbine, of fifty-six inches, with a fall of seven feet, was used. The number of revolutions is not given. Twenty-three Smolts were put in the turbine-pit, and after ten minutes the net was raised. In it were six living Smolts, six dead and two dying; four "mashed up"; one living Trout of 1¾ lb.; one Eel about ½ lb. There were no marks of injury in the living, dead, or dying Smolts. Sir Thomas thought the marked Smolts had been subjected to two or three revolutions, while the Trout had been in the tail-race before the net was fixed. He does not express any opinion as to the effects of the turbine on the fishes.

In the third experiment (at Mr. F. Wookey's mill) a Hercules turbine of twenty-one inches, three hundred and twenty-five revolutions, and a fall of twenty-eight feet was used. The net

was fixed in the tail-race a considerable distance below the discharge from the turbine. Thirty-one Smolts were placed in the turbine-pit. In twenty minutes the net and box were examined. In the box were ten Smolts—one alive, one decapitated, one with neck injured, and seven dead without marks. Another was taken out of the tail-race with its head crushed and partly severed. The large number (proportionately) which passed through the turbine in twenty minutes is noteworthy. Vigorous fishes often resist the suction of the turbine for a longer period.

The fourth experiment was at Coagh Mills (Messrs. Duff's), with the large Sabelly turbine, seventy-two inches in diameter, and with thirty-eight revolutions per minute. Instead of the ordinary net, Sir Thomas Brady used a wire-net on poles leading into a box in the centre, fixed and held in the tail-race as close to the turbine as possible. Six Smolts were placed in the pit whilst the turbine was working. No Smolts were captured. Water, however, broke over the netting, and may have carried fishes away. Three Smolts were seen shortly afterwards swimming over the case of the turbine, and about it, when the turbine stopped.

In the fifth experiment a McAdam turbine in the same mill (Messrs. Duff's), of sixty inches in diameter and sixty-five revolutions per minute, was used. The ordinary net and box with perforated zinc were placed "at a convenient distance from the turbine." Eight Smolts were placed in the turbine-pit. In fifteen minutes the net was raised. Two Smolts were found in the box alive, one Trout dead and with its head injured, "but it was quite evident that it had not been recently killed." In this as in the others no examination appears to have been made of the turbine-pit.

Sir Thomas Brady concludes :—"I got so very few fry alive that I cannot help thinking that they must have been killed at once as they went through, and dropped into the deep water below as they were struck. I used such precautions that I do not see how the fry could have escaped my net otherwise. In two places I admit they could." He said, further, that the danger would be increased where hundreds and thousands were "whirled round and shot out again." He had seven or eight men from Lucan, including Mr. McDermott, a mechanical

engineer, assisting him; yet it was most difficult to make a satisfactory test, and he stated that his was not so thorough as he could have wished. Moreover, he had difficulty in keeping the fishes alive. Some were procured from Sion Mills, on the Mourne, and he lost many. Those he used, however, were in good condition.

In considering these experiments it must be borne in mind that the turbine-pit does not appear to have been searched after the machinery was stopped, and no details are given of the stream flowing into the pit in connection with the possibility of escape thereby.

The following series of experiments was carried out on the 15th August, 1900, at the Stormontfield Bleaching and Calendering Works of R. W. Mackenzie, Esq., on the Tay, and whose kind permission deserves due acknowledgment. The first turbine experimented with was a 24-in. Hercules turbine. The turbine-pit is supplied by a "leat," which is guarded by iron bars two inches apart, and the water falls about 8 ft. into the concrete pit, which is about 8 ft. square and 12 or 13 ft. deep. The revolutions of the turbine are 250 per minute. After rushing through the blades of the fan the water escapes by the tail-race. The latter was carefully guarded by a fine-meshed pollan-net, and further down the stream the fine median gauze of a sand eel-net was stretched across. The stream was easily inspected from the purity of the water, and it was confined to this turbine.

(I.) At 10.40 a.m. a tank containing fourteen Salmon-Trout and Trout, ranging from ¼ lb. to about 3 lb. in weight, was emptied into the turbine-pit. Two of the Salmon-Trout had been injured by the net in capturing them, and floated with their bellies uppermost in a moribund condition in the small tank. In fifteen minutes one of the latter, about 15 in. long and weighing 1 lb. 2 oz., was taken (dead) from the "leat." It had dropped to the bottom of the turbine-pit, and had not sufficient vitality to keep out of the suction-current. Its surface presented only slight abrasions of scales, caused in all probability by the net used in capture, or in handling to replace it in the tank from which it had leapt during the night. So far as could be detected there was no injury to bony structure, and no ecchymosis was visible. The viscera were healthy, with the exception

of the posterior third of the liver touching the left abdominal wall. Such may have been due either to pressure in handling or to the turbine. The brain, heart, and ovaries were normal. On dissecting the muscles from the vertebral column an ecchymosed region was found along the tips of the neural spines in front of the first dorsal fin, and another smaller area over the neural spines in front of the tail. It is not certain, however, whether these injuries were due to the turbine or the ring of the net in capture.

In two or three minutes the second and smaller Trout (of the two already alluded to) came down the tail-race, apparently lifeless, though when taken out the mandible moved once or twice. Its surface showed similar slight abrasions, but no lesion to osseous structures could be discovered. The posterior third of the liver was ecchymosed, but no rupture was visible. All the other organs were normal, the ova in the ovaries being somewhat less than in the previous example. Further minute examination disclosed a slight ecchymosis in the tissues over the neural spines in front of the tail.

An efficient watch and a diligent search of the tail-race and nets proved that none of the other Trout had passed through and entered the tail-race. A pole was also used in the turbine-pit to drive them towards the suction area, but without effect. They resisted the currents and avoided the pole. The men, indeed, asserted that they occasionally find Trout in the turbine-pit, and they considered that some of these remained therein for a long time.

(II.) At 11.42 a.m. fifty vigorous yearling Lochleven Trout were put in the same turbine-pit where the rest of the larger Trout still remained, and the turbine went steadily on, the flow of water being equable. In thirteen minutes two of these Trout appeared in the tail-race, and at intervals one or two darted down stream. All were in full vigour and capable of taking care of themselves. So few appeared that the pole was several times put in operation in the turbine-pit. In thirty-five minutes about eight had passed down stream, and two were under the stone arch. Subsequently one would dart downward so quickly that even in the pure water it was difficult to see it. After a further period of half an hour the water was turned off the

turbine and the tank nearly emptied, only seven inches of water remaining on the bottom, and this was full of fragments of sticks, grass, leaves, and plants of various kinds. Dr. H. M. Kyle, of the Gatty Marine Laboratory, and Mr. Lumsden, Superintendent of the Tay Fisheries, carefully searched the turbine-pit with hand-nets, and secured seven small Lochleven Trout (of the fifty), and eight of the larger Trout captured by Mr. Lumsden in the Tay. The largest fish—a Salmon-Trout of 3 lb.—was not in the tank, so that it must either have been in the turbine, which the men did not think probable, or it had escaped observation. If it had been killed its dead body, either entire or otherwise, could not have escaped observation in the clear water of the tail-race. The two gentlemen above mentioned also waded up the tail-race, but caught no Trout, though a few swiftly darted down stream.

The two nets were now examined. No fishes occurred in the pollan-net, the small and nimble Lochleven Trout having passed through its meshes. Seven Lochleven Trout (of the fifty) were captured in the sand eel-net. The rest had evidently escaped at the edges or underneath it, for many passed down stream, and it was difficult to retain such active forms. No trace of an injured or sickly example was seen.

During this experiment some of the small Trout were noticed near the fry-guard put over the 2 in. guard of iron bars of the head-race, showing that they can get out of the turbine-pit when they please. Indeed, at a subsequent experiment one came outside the iron bars (the fry-guard having been removed), but darted inward again as soon as it noticed a figure at the edge of the stream. The men stated that the Trout often get out of the pit in this way when it is full of water, and the fall from the stream is slight. On the other hand, Kelts of 24 in., as they descend, may, if the bars are too wide, get into the turbine-pit, and the sickly ones are occasionally killed.

(III.) As the works also possessed a powerful breast-wheel, 8 ft. in breadth at the edge, in two sections, and with "buckets" 13 in. across, it was thought desirable likewise to investigate its action in connection with the Smolts. Moreover, connected with it was a regulator (said to be a somewhat rare appendage to a water-wheel), which manipulated a sluice, opening or closing

it according to the flow of water. Unfortunately only a few Trout were now available, and all had been used in the previous experiments, and some of those removed from the *débris* at the bottom of the turbine-pit had been injured. At 3.20 p.m. four Sea-Trout, over 2 lb. in weight, and seven of the smaller Lochleven Trout were placed in the rushing current of the breast-wheel, close to the "buckets." One or two were sickly, and one appeared to be dead. In a few minutes the dead Trout came into the swift tail-race. No trace of the others appeared. If the others had been killed, their bodies would in all probability have been discovered in the tail-race. So far as could be observed all the living had escaped serious injury. It was stated that occasionally Trout are crushed between the wall and the edge of the wheel, but in this case they were in the middle of the current.

The next experiments were carried out at the Maine Works, Cullybackey, Ireland, September 25th, 1900, in the presence of Mr. Hely Hutchinson, the Secretary of the Commission, Mr. McDermott, Mr. King, and various fishery officers. The head-race here is a capacious one, and the water passes through sluices on the right bank, then through a grating of vertical iron bars from ¾ in. to 1¼ in. apart, according to curvature, and with their convex edges to the stream, and then falls into a turbine-pit, 19 ft. deep by 12 ft. broad, close to the wall of the mill, and, indeed, proceeding under the building for some distance before reaching the Hercules turbine, which makes one hundred and thirty-seven revolutions per minute. As the Trout had previously resisted the suction of the turbines, and apparently only were drawn in voluntarily or when dead or enfeebled, a tube of wood 22 ft. long by 9 in. square had been prepared, with a forward bend at the bottom, so as to convey the fishes as near the turbine as possible, and thus compel them to pass through it.

(IV.) About forty mixed Trout, from 4 in. to 6 in. in length, and consisting of Lochleven, Rainbow, Brook, and Common Trout, were placed in the wooden tube at 1.30 p.m., and shortly after a pailful of earth was sent after them. Further, a chimney-sweeper's brush (unguarded) was passed down the tube, which had its bent extremity in close proximity to the turbine, so as to send them out. In five minutes a Trout struck the net placed

in the tail-race. Mr. Armitstead reported that when the brush was withdrawn from the tube several Trout were brought up, and an inspection of the tube showed several Trout swimming at the surface of the water. Subsequently it was stated that the head had separated from the brush, and was at the bottom of the wooden tube, and that the man in charge of the brush had moved it up and down the tube with vigour before the head separated. The net in the tail-race was of fine twine with $\frac{3}{4}$ in. mesh, and the centre extended into a pocket. It was fixed at the platform near the edge of the stone arch, and from its situation and the curve of the tail-race the pocket streamed toward the right bank. The bottom or sole-rope was furnished with pieces of lead, and in addition heavy iron bars caused it to cling to the bottom. The brownish hue of the water (from peat) made it difficult to see the fishes, and was in contrast to the pure water of Stormontfield.

On stopping the turbine after fully half an hour's work and examining the net in the tail-race, only a single fish, having an eye destroyed, was found in it, and in all probability this injury was due to a stiff fibre of the brush penetrating it in the wooden box. When the long wooden tube in the pit of the turbine was drawn up, five living fishes were found in it, and one crushed, the latter having been struck by the heavy brass end of the head of the brush after it became free. When the pit of the turbine was emptied twenty-two active fishes were taken out, and one dying, the latter having been struck by the landing-net. All these had resisted the suction of the turbine, and might have remained in it for weeks until an opportunity for escape presented itself, and it was noteworthy that they were more readily caught by the hand-net at first, but as soon as they understood the purpose of the net it became difficult to secure them. Captain Dannevig had the same experience with the adult Cod in the spawning-tanks at Floedevig, in Norway. The great fall of the water into the turbine-pit was a feature in this mill. Further, it was clear that a naked chimney-sweeper's brush is a dangerous piece of apparatus to use amongst young Salmonoids.

(V.) At 2.58 (Irish time) one hundred and seventy-five Trout of the kinds and sizes before-mentioned were placed in the same turbine-pit when three-fourths full. The pit was completely filled

at 3.1 p.m. In a few minutes a number of the Trout appeared in the tail-race, and they continued to drop down at intervals. Shortly after commencing, however, the right pole of the net in the tail-race gave way, but in a few minutes (five) it was put in position and fixed. In half an hour the net in the tail-race was lifted, and a dead fish dropped from it, whilst a few escaped from the pocket. Only one of those put in was secured, though two Parr, considerably larger in size, were captured, but these may have come only from the tail-race. Many of the young Trout of the series placed in the pit were observed at the right wall of the tail-race above the net, but though Mr. Armitstead carefully fished, after stopping the turbine, the tail-race above the bridge to which the net had been fixed, he caught none. They were too nimble in the dark water.

The turbine-pit was in this instance emptied by a great rush outward, and unfortunately every Trout was swept out with the current. No dead or mangled fish was observed in any part of the apparatus, with the exception of that already mentioned.

(VI.) The sixth experiment took place at Mr. Webb's Mills, Randalstown, Co. Antrim, on September 26th, 1900, with one of a pair of turbines situated in a large chamber (pit), into which the water had a fall of 12 ft., entering from a wide sluice-gate through iron bars. By the inexperience of the men to whom Mr. Armitstead had committed the charge of the Trout (for he had missed the night-train), the box—containing two hundred and fifty Trout 4–6 in. in length—was carried under the gates, and all escaped except twenty-two. At 12.48 p.m. the twenty-two Trout were placed in a box having a bottom of perforated zinc, with various holes in the sides and lid, and with long stays or struts reaching to the platform, where they were held. The lid was hinged, and could be lifted by a cord, so that the Trout on escape were within the powerful currents entering the apertures of the turbine. The fishes were thus brought close to the apertures of a 33-in. Achilles turbine, having one hundred and twenty-five revolutions in a minute. During the first few minutes of the experiment, indeed, the revolutions were three hundred per minute. As the machinery was used solely for electric light, a steady rate was necessary. The tail-race led into a broad open pit, from which the water

coursed through two arches of 6 ft. and 7 ft. respectively, and with a median pillar between them. These were guarded by wire-netting of $\frac{1}{4}$-in. mesh, attached to a framework of wood about 15 ft. long by 4 ft. deep. The floor of the race above the netting was temporarily paved with broad boards of white wood held down by large iron weights, for the purpose of showing the Trout as they passed. The deep brown hue of the water, however, rendered this device of little avail. The fine wire-netting, nevertheless, demonstrated one thing, *viz.* that a great current of water flowed easily through it without interfering with the working of the turbines. Leaves, grass, and *dêbris* would necessitate cleaning, but they did not stop the current. Everything worked smoothly for twenty minutes, but as not a trace of a Trout was observed, the machinery was stopped. An examination of the tail-race—now in quietude—showed numerous small Trout (of the series put in the turbine-pit) in the shallow part, but none went near the white boards. Amongst them were several larger (7–8 in.), which must either have been in the tail-race previously or passed through the turbine—probably the former. On the fine wire-netting was a single dead Trout, which had been carried against it when in a sickly condition by the current. The same occasionally happened at Stormontfield breeding-ponds in the case of even active but very young fishes. In the pit of the turbine one hundred and fourteen young Trout were captured, besides three which were killed by the hand-nets in the process. As usual, they resisted the powerful suction caused by the turbine, and preferred to remain in the pit.

(VII.) At 2.25 p.m. thirty young Trout were placed in the perforated box, and lowered to the edge of the other Achilles turbine, one of the most modern type, 48 in. in diameter, and 170 horse-power, with eighty to ninety revolutions per minute. In working this and the previous turbine it was found that water escaped in considerable quantity from the upper part of the pit of the turbine, but it was stated that no Trout could pass through. This flow by-and-by became less. The machinery started at 2.47, and in a few minutes the rush of water in the tail-race carried away the left guard so as to leave a gap of 20 in., and, as this could not readily be repaired, the experiment was necessarily imperfect. When the box was pulled out of the

turbine-pit a single living Trout was in it, whilst in the turbine-pit a considerable number of Trout (twenty to thirty) remained, partly from the previous experiment and partly pertaining to this. No dead fish was seen.

(VIII.) In this instance a 48-in. Leffell turbine, having ninety revolutions per minute, was used. The pit of the turbine was 8 ft. square by 9 ft. deep. Sixty-two Perch, about 4½ in. to 5 in. long, were placed in the box formerly described, and released close to the edge of the moving turbine at 3.45 p.m. In a minute and a half one or two passed into the net at the tail-race, and in four minutes another struck the ladder at the net. Many leaves, weeds, and other *débris* were carried into the tail-race where the net was placed, about 25 ft. from the turbine. In eleven to twelve minutes the revolutions of the turbine were slowed to fewer than eighty, and again increased in velocity. At 4.12 p.m. they were seventy per minute. By clearing the iron guards, between each of which there was a space of 1¼ in., the flow of water was increased, and the number of revolutions was eighty-six. The machinery was stopped in forty minutes. In the net stretched across the tail-race were thirty-eight Perch in fair condition, which were placed in water for further experiments. All these had passed unscathed through the turbine. No dead or wounded Perch could be found, for the turbine-pit was thoroughly searched by Mr. Armitstead, and no trace of a fish was found in it. These fishes (Perch) are, compared with the agile Trout and Smolts, stiff and rather thick fishes; yet, so far as could be ascertained, the mortality was trifling. A considerable number probably lay in the tail-race above the net, or had escaped by chinks at the side.

(IX.) Into the same turbine-pit, at 5.15 p.m., one hundred and thirteen mixed Trout were placed by aid of the box close to the apertures of the turbine in action. In five minutes the revolutions were seventy per minute, in four minutes after eighty revolutions; at 5.25, seventy revolutions, and in three minutes thereafter eighty-six revolutions. These irregularities were due partly to changing gear, and partly to the clearing of the iron guards of the head-race. The machinery was stopped in twenty-nine minutes. Out of the net came three Perch which had passed through the turbine in the previous experiment, and

had been lurking in the tail-race, a Gudgeon, and one wild Parr from the tail-race (which had not passed through the turbine). No trace of the mixed series of Trout was found either in the net or in the turbine-pit, which was carefully searched. Some may have lurked in the tail-race, but it is unlikely that all could have been thus disposed of. It is possible that these agile and active fishes escaped by the head-race, but this could not be proved.

(X.) The conditions connected with this and other experiments at Bushmills were altogether different from the previous experiments. The mill is used for generating the power for the Giant's Causeway Electric Tramway, and it is situated at the Bush Falls, about a mile above Bushmills. At this point there is a steep cataract on the river, with a total average fall of 25 ft., which is the fall used for working the engines. The head-race, having an average depth of 5 ft., is led from a point about sixty yards above the highest reach of the falls to the turbine-chamber, whilst about forty yards above the latter is a by-wash for excess-water, immediately below which (and in the head-race) is a 2-in. bar fish-guard, placed at an angle to the stream. Below this is the main sluice of the race, which is so constructed that the remainder of the channel can be completely emptied. A short distance above the turbine-chamber is a small valve or sluice in the bottom of the race, which removes any water collecting there. The up-stream face of the turbine-chamber is protected by a fry-guard of a fine mesh.

Before detailing the experiments it is well to explain the peculiarities connected with the turbines at Bushmills. An Alcott and a Hercules turbine are placed side by side at the bottom of a precipitous cliff, a little below the falls of the river. As mentioned, the head-race is taken from the falls, and the water is conducted by a deep channel to a turbine-chamber, 18 ft. by 8 ft., and 6 ft. deep, and this, as stated, is guarded by strong wire cloth originally of $\frac{1}{4}$-in. mesh, but certain wires have been removed, leaving, as a rule, two together transversely. In some places a space of a square inch occurs, so that a Smolt could escape into the head-race, and *vice versa*. The water is conveyed to the turbines by two nearly perpendicular shoots constructed of old boilers, each with a butterfly valve at the

top. The descent is 26 ft., and, further, the water is confined round the turbine by a case of cast-iron, so that it can only escape by the tail-race. The arrangements, therefore, differ considerably from those hitherto met with, since the Trout have to be transmitted along the iron shoots, and have no option in the cavity of the turbine but to pass through. Moreover, in the Alcott turbine this space is limited, its widest part at the top being 9 in., and it narrows to 2½ in. at the bottom, so that there a Trout could not swim with its head at right angles to the rim. Within the foregoing iron case are the fixed gates, which are set obliquely. These, again, enclose the movable gates, which can be adjusted so that more or less water enters by a cog-wheel working within a limited space marked by stops on each side. The centre is occupied by the revolving vanes with the spindle in the middle, the vanes having a diameter of 27 in. There is little or no space between the revolving centre and the case outside, so that the fish, unless it enters obliquely with the water, could not escape injury. When fully open the oblique aperture seemed to be about 2 in., as the band could pass freely.

(XI.) The Alcott turbine was first experimented with, at two hundred and fifty revolutions per minute. At 1.6 p.m., September 28th, 1900, fifty mixed Trout (Lochleven, Rainbow, and Brook) were placed in a square wooden shoot or tube which passed the butterfly valve. The fishes were gently pushed out of the tube by a sweeper's brush covered with cloth, but this was not satisfactorily done. When fresh cloth was procured the fishes, some of which swam at the surface of the water in the wooden shoot, were more dextrously pushed out of the tube. The net had been previously fixed to a framework erected close to the escape-pipe from the turbine. In this case peculiar eddies carried the upper part of the net inward, and, indeed, the tail-race at this part was a surging mass of water, as if boiling. This was partly due to the swollen condition of the tail-race and the river, which was about 4 ft. above its normal level from a flood. The turbine was stopped at 1.45 p.m.—that is, after more than half an hour's work—and the head-race was emptied. Out of the net came two uninjured Trout and three dead. One of the dead dropped from the net into the water and was lost. The other was caught in a pail. One of the dead fishes

had lost an eye, probably from injury by unskilful use of the brush in pushing it out of the wooden shoot, another had its gills exposed by removal of the head, while the third had its body crushed behind the pectorals, the skin being drawn over the ruptured muscles. A fragment of a candle about 2 in. in length was also in the net. It had been put in the shoot by Mr. McDermott. No trace of the rest of the Trout was seen, but the dark, surging water prevented minute observation, though the bodies of the dead would readily be carried against the net. There was ample opportunity for the concealment of the living in the tail-race.

(XII.) The next experiment was with the Hercules turbine of about seventy-five horse-power, and having two hundred and fifty revolutions per minute. In this instance the wooden shoot or "trunk" was lowered 6–8 in. further into the iron shoot, so as to bring the fishes more directly into the current. At 2.57 p.m. fifty small Trout and four larger (9 in.) were pushed through the wooden shoot, along with a candle to which lead was attached, the total length being 6½ in. The current issuing from the Hercules turbine was less involved than in the previous case, so that the bag of the net was carried out more satisfactorily. At 3.10 p.m. a portion (about 2 in.) of the candle appeared in the water around the turbine, and ten minutes later the rest of the candle floated out. It seems that Mr. McDermott thought that by attaching a string and a leaden ring the specific gravity of the candle would be adjusted to that of a fish, but this probably caused its fracture. The turbine was stopped at 3.25 p.m. In the net at the tail-race were two injured fishes which lay on their sides. The larger was bruised behind the gill-cover, and the smaller had a pale patch about the middle of the body below the first dorsal fin. Both were paralysed. The larger fish soon died, and the smaller remained paralysed.

In the turbine-pit on the top of the cliff a single large Trout was found. The rest of that size had passed through either during the action of the turbines or subsequently. Of the smaller series, one was captured in the pit, but others were observed gliding over the rim as the water rushed down the shoot.

(XIII.) The same turbine was employed in this experiment.

As the larger Trout (six in number) had again been lost in the stream by careless fastening of their box, only small Trout of the same size as previously were available. Fifty of these small Trout were pushed through the wooden tube, as before, at 4.36 p.m. The turbine was kept in action for half an hour. No fish occurred in the net, showing that the Trout had either lurked in the tail-race or had escaped by chinks. Fragments of lacerated forms would in all probability have been carried against the net by the currents. In the turbine-pit a single example was secured, but others were observed escaping by the iron shoots. These had refused to be carried down the shoots during the action of the turbine. A single large Trout appeared behind the wire guards as the man entered. It had either lurked in the pit after the previous experiment, or found an aperture large enough for entrance, though the latter is unlikely. It could scarcely have passed up the iron shoot.

(XIV.) In this case the Alcott turbine was employed. At 5.46 p.m. fifty small and two larger Trout were pushed as before down the long wooden tube into the iron shoot. The eddies in the tail-race, as previously, pushed the upper part of the net inward, and thus it was less fitted for service. The turbine was in action for half an hour, and was then stopped. On raising the net a portion (4 in.) of the posterior end of a large Trout was found. Such evidently had been lacerated in the turbine. No evidence of the smaller Trout was obtained.

(XV.) Both turbines (Alcott and Hercules) were put in action at 6.30 p.m., and, the wooden tube having been removed, fifty-two small Trout, two Perch, and one larger Trout were placed in the general cavity of the pit, which had both butterfly valves open. The fishes thus had perfect freedom in the large cavity formerly indicated. The current rushing out at th tail-race floated the bag of the net more satisfactorily than w..en either turbine was worked singly. The turbines were stopped in twenty-five minutes, as darkness was coming on. Only a single Perch, devoid of its head and with the body split, was in the net. Two small Trout were caught in the turbine-pit, whilst three or four escaped over the edges of the iron shoots as the water drained off. As before, these and probably others declined to be drawn into the vortex over the shoots. In the ordinary working

condition of these turbines comparatively few Smolts could find entrance into the turbine-pit if the wire-netting is left intact. The removal of some of the strands, however, may admit some into the chamber. One difficulty in experimenting with these turbines was the backwater and flooded condition of the tail-race.

The succeeding experiments were made at the Anna Liffey Mills (corn and flour) of Messrs. G. Shackleton and Son, October 2nd, 1900. The supply of water comes from the Liffey by an oblique and rather long dam, from the lower angle of which a deep (6–8 ft.) head-race, about 8 ft. broad, runs to the first building (wood), where the race is guarded by strong iron bars, which seem to have been originally about 3 in. apart. It flows through, turns to the left, and reaches the turbine-pit after a fall of 6½ ft. The turbine is an Alcott, 60 in. in diameter, and of forty horse-power, with fifty to fifty-two revolutions per minute. Here, as elsewhere, considerable difficulty was experienced in fitting on the net at the tail-race, close to the exit of the water from the turbine, this position being chosen so as to minimise the chance of the Trout escaping observation in the tail-race, which had to be reached by crawling under beams after descending the ladder at the turbine. Notwithstanding the energetic efforts of Mr. Shackleton, Junior, a gap of about a foot was left at each side of the net.

(XVI.) At 1.57 p.m., on October 2nd, 1900, fifty small Trout from 4 in. to 5 in., and consisting of a mixed series of Loch-leven, Rainbow, Brook, and two large Rainbow Trout of 9 in., were placed in the long wooden tube, the lower end of which was close to the "gates" of the turbine, and all were pushed out by the brush with its cover of cloth. In half an hour the net was examined and five living Trout secured, besides two Parr of 6–7 in., which did not pertain to the official series. Doubtless others escaped through the meshes of the net, or by the gaps at the side. No dead fish was observed.

Mr. Shackleton stated that he had seen Smolts coming down the river tail first, then enter the head-race, become suspicious, turn back, and finally go over the weir. Salmon swim up the water over the weir, not leap up, in a full river.

During the forenoon the mill above this (*viz.* Mr. Hill's) was not working, so that a full supply came downward, but in the

afternoon the case was altered, the upper mill being in active operation. The river consequently was so much lowered that no water flowed over the dam, which was composed of stones with a coping of concrete, the latter also forming the sides of the head-race. The diminution of the river caused the Trout to descend to the deeper pools below the dam.

(XVII.) At 3.22 p.m. a hundred mixed Trout, as before, and two larger (9 in.) Trout were pushed down the wooden shoot (12 ft. long), which had on one side of the extrémity an opening next the turbine. The fishes were thus compelled to escape into the water around the turbine. At 3.25 p.m. a Common Trout, 13 in. long, and well-nourished, was also sent down, and the aperture plugged by the brush with its cotton covering. At 3.40 p.m. an Eel, 13 in. long, was marked by having the tip of the tail removed, and also put, by aid of the shoot, in the vortex of the turbine, the speed of which was fifty revolutions per minute. In drawing out the brush from the wooden tube for the purpose of inserting the Eel, a small Trout came up uninjured on the top of the cloth covering the fibres. This shows how tenaciously they cling to any place of safety under trying circumstances. After fully half an hour's work the net was found to contain ten small Trout, the largest, a Rainbow Trout, being 6 in. long, and the Eel—all uninjured. The rest either remained in the turbine-pit or escaped by the gaps at the sides of the net. No sign of an injured Trout appeared.

When the water in the river was lowered in the afternoon by the resumption of work by Mr. Hill's mills above (parts having been under repair), the stones along the foot of the weir at Anna Liffey Mills were left dry, and Mr. Armitstead was able to capture the Trout and the Eel without difficulty. The fishes made off rapidly, as the river became low, for the deeper pools beneath. On the conclusion of the experiments a Pike, about 5 lb. in weight, was noticed swimming upwards in a pool. One of the men, taking an iron pipe, waded into the stream, drove the fish to shallow water, and killed it by blows on the head. It was a male with well developed milt. No food was found in the stomach, and little in the intestines. The removal of water is important in connection with the welfare of the Salmonoids, which are thus placed at the mercy of persons disposed to

interfere with them. A large Salmon, though much more active than the Pike, the right eye of which suffered from corneal opacity, would have fallen a prey to poachers.

Experiments at Messrs. Hill's Woollen Mills on the Liffey, October 3rd, 1900. The water is brought from the Liffey, across which a long oblique dam is placed below the bridge, the head-race or "leat" conveying about a third of the water in the river. A fish-pass exists at the end of the long dam nearest the bridge, but the plan is somewhat old, the steps being short, so that with one or two exceptions the fishes could not rest in their progress upward. At the top of the weir a board about 8 in. deep had been put into a groove in the concrete, so as to dam up the water for the purposes of the mill. This appears to require attention. The fall from the weir seems to be 10 ft. or 12 ft.

The turbine is an Alcott, 60 in. in diameter, and of seventy horse-power, with seventy-four to seventy-six revolutions per minute. It is placed in a pit 12 ft. deep and 12 ft. square, and is with difficulty reached for observation. After clearing the hole in the floor for fixing the net in the tail-race, a steam-vat formed a step to the greasy beams. The wooden shoot used at Anna Liffey Mills was courteously brought by Mr. Shackleton, who yesterday and to-day exerted himself in many ways to aid the Commission—for example, by bringing a skiff and boat, both of which were of material service in the underground and expanded tail-race. Without such aid the work would have been done much less expeditiously, if it could have been accomplished at all. The roof over the turbine-pit was so low that only one length of the sweeper's brush could be manipulated at a given time. It was intended to fix the net close to the edge of the turbine-pit, but this was found, after persevering efforts by Mr. Skackleton and others, to be unsuitable, since the strong current and absence of points for fixation prevented the net closing the space satisfactorily. It was therefore fixed across the stone arch about five feet from the edge of the pit. The great strength of the current probably sent the majority of the fishes which passed the turbine into it, though a gap of a foot, due to irregularities of the masonry, existed at each side. Every mill presents certain difficulties of its own, and without the use of a boat the

net could not have been adjusted; moreover, Mr. Shackleton was thus enabled to enter the tail-race from the rear, a distance of about eighty yards. A lining of fine gauze was placed in the bag or pocket of the net.

(XVIII.) At 2.53 p.m. fifty small Trout, 4–5½ in. long, two Parr, and two larger Trout (9 in.), were placed by means of the wooden shoot close to the turbine, and thrust out by means of the brush covered with cloth, which was left so as to block the return of the fishes. At 2.40 p.m. the net was reached from the rear. The strength of the current had entangled the bag of the net, and carried the end under the leaden weights in front, and the force used in extricating the net apparently had caused the death of a large Trout, which had no external signs of injury. A living Trout (small) was also in the net, but the condition of the net was such that it was difficult for any Trout to enter, since it formed a loop on itself. The end of the net had not been fixed by the cord. In all these experiments also it has to be borne in mind that, while a dead fish might be held by the meshes, they permitted the egress of small active Trout.

(XIX.) At 3.25 p.m. one hundred Carp of an average length of 5 in. were pushed down the wooden shoot close to the openings of the turbine. The conditions and the number of revolutions were the same as in the previous experiment. At 4.5 p.m. the net was taken up with the following fishes, all of which were uninjured: fifty-six Carp, three small Trout, which had passed the turbine either now or during the former experiment, *viz.* one Lochleven, one Rainbow, and one Brook Trout. Two of the living Carp were left in the net.

(XX.) The next and last experiment took place at 4.38 p.m., when the following fishes were pushed through the wooden shoot close to the apertures of the turbine: Fifteen small Trout (mixed), fifteen small Trout (mixed) used formerly in the Anna Liffey Mills, five Rainbow Trout 9 in. long, one Parr 6 in. in length which already had been twice through turbines. The turbine made about sixty revolutions per minute. At the end of half an hour there were in the net: Two Carp, formerly left in it; one Parr, 6 in. long, which thus for the third time passed through turbines; nine small Trout, consisting of Lochleven, Rainbow, and *S. fontinalis*. All were in perfect condition. On

removing the wooden shoot from the turbine-pit, after withdrawing the plug formed by the sweeper's brush covered with cloth, there were found in it thirty-six small Trout and one larger Trout (9 in.), all in good condition. They had taken refuge in the cavity from the vortex near the turbine after removal of the foregoing plug. The interior of the tube would in all probability be the only quiescent region in the pit.

Remarks on the Foregoing Experiments in August, September, and October, 1900.

In all the experiments, which were twenty in number, one feature was marked, *viz.* the comparative ease with which healthy Trout in the turbine-pits kept free from the vortex caused by the action of the turbine. They appeared to go through the turbine only when they pleased, or by accident. Moreover, when circumstances were favourable, they swam out of the turbine-pit to the head-race, and thus, as at Stormontfield after the fry-guard was removed, could have passed up-stream to the nearest by-wash, if such existed. Large Trout as well as small seemed te hold their own in these pits, which varied in size from eight feet square to more than double the dimensions. This feature, which was noticed in the first experiment as well as in every subsequent one, might readily account for the absence of fry in the nets in the tail-race, and will explain some points in Sir Thomas Brady's experiments. The disappearance of the large Salmon-Trout in the first experiment at Stormontfield is to be explained either in this way or by supposing that it was caught in the turbine and held. As it weighed about 3 lb., some indications of its entanglement in the turbine would have been forthcoming during the four or five hours in which the tail-race was closely under supervision. It certainly was not in the turbine-pit nor in the tail-race. That Trout, and consequently Smolts, surpass certain other fishes, such as Carp and Perch, in the vigour and dexterity of their movements was plain—from the comparative rapidity with which both of the species mentioned (Carp and Perch) passed through the turbines and appeared in the net. The larger and more wary Sea-Trout and Trout, from ½ lb. to 2½ lb. in weight, declined to enter the turbine, and

either kept the turbine-pit, or probably passed by the head-race upward through the 2-in. spaces between the bars when it was in their power to do so. The smaller Trout also refused in many cases to leave the turbine-pit, even though long rods were moved in the water to drive them downward to the turbine. They preferred the gently moving water of the pit to the vortex at the edge of the turbine or the flow from the head-race, yet when they had the shelter afforded by the wooden trunk or tube in the midst of the pit, they chose it, and hence the numbers present when the trunk was drawn out. As the head of the chimney-sweeper's brush was enveloped in cotton cloth so as to make a rammer to fit the tube or trunk, and as it was kept in most cases in position at the bottom till the experiment was finished, it is clear that, as at Messrs. Hill's at Lucan, the Trout had returned to the shelter of the trunk after removal of the rammer a few minutes before being drawn up. The ramming of the Trout out of the trunk directly into the currents rushing into the turbine required care, so as to prevent the Trout gliding upward above the plug of the rammer. It was best done slowly, and with water poured in from above. In the first experiment at Cullybackey the head of the brush was unguarded, and the fibres injured the Trout (removing an eye), whilst the loose brass end crushed others beneath it. The Trout readily rose above the unguarded brush, and appeared at the surface of the water in the trunk, and, even when guarded, unskilful use was followed by the appearance of a few at the surface of the water in the tube.

Less active fishes than Trout pass out of the pit through the turbine more quickly. Thus, for example, more than half the Carp were caught in the net at Lucan in half an hour. Many others probably escaped by the sides of the net, which could not be closely fitted to the walls of the tail-race. These stouter, stiffer fishes would have suffered more severely than the Trout if the turbine had inflicted injuries on them.

In reviewing the different forms of turbine, it would appear that those of the type of the Hercules turbine, placed in a pit of some capacity and with a moderate and free fall, have, as a rule, comparatively little effect on Trout of a size approaching Smolts, and, further, that fishes of a size considerably larger may pass

through unscathed. The passage of moribund Sea-Trout (15 in. long and 1 lb. ½ oz. and 13 in. long, respectively) through a 24-in. Hercules turbine, with two hundred and fifty revolutions per minute (Stormontfield), with comparatively slight lesions, gives a considerable margin to the Smolts, if they should pass the ordeal. On immersion these moribund fishes fell to the bottom of the turbine-pit, and were drawn in at once.

Where the Hercules turbine is in a deeper pit, as at Cullybackey (19 ft.), and Bushmills (26 ft.), accidents are more liable to take place, though it cannot be said that the mortality at Cullybackey was serious (barely 1 per cent. on the total). The unskilful use of the unguarded sweeper's brush in the wooden tube caused greater loss. At Bushmills the closure of the turbine case and the great depth (26 ft.) of the iron shoots were unfavourable, and caused the losses detailed. The fishes in the pit above the shoots could prevent themselves from passing down just as in the other cases, and under ordinary circumstances the wire-guard would probably have shut them out. As the turbines at Bushmills were apparently the most destructive met with, it may be well to examine the results in greater detail, premising the remarks by observing that the net throughout fished unsatisfactorily—from the swollen condition of the river and the tail-race, which was 4 ft. above its usual level. Besides, the small size (Alcott, 27 in., Hercules, 18 in.) and considerable speed (two hundred and fifty revolutions), as well as the almost vertical iron shoots of 26 ft., placed these turbines on a different footing from the others. The small number of Trout captured below the turbines, further, is noteworthy, and probably was due to the unsatisfactory condition of the tail-race for experiment.

In the case of the Alcott turbine, there were three dead to two living Trout (out of fifty) in the first experiment, and only 4 in. of the tail of one of the larger Trout in the second experiment. In the first experiment with the Hercules turbine two injured small Trout only (out of fifty small, and four of 9 in.) were obtained by the net. In the second experiment none were recovered by the net. No fragments of Trout were seen in the surging water near the turbines, though a careful watch was kept throughout the experiment, and a search with a hand-net subsequently. When both turbines were in action the captures

by the net were as scanty, for out of fifty-two small and one large Trout and two Perch, only a single crushed Perch was obtained after twenty-five minutes' work.

The experiments at Bushmills, while demonstrating the dangers to Smolts, did not sufficiently show the fate of those passing through the ordeal alive. As in former experiments, both large and small Trout in the turbine-pit resisted the suction downward.

Turbines of other forms (such as the Alcott and Leffell), standing in ordinary pits with a moderate fall, and with sixty to eighty revolutions, have slight effect on fishes of the size of Smolts. Even less active and supple forms, like Perch, escape serious injury. A Parr as large as a Smolt may be sent through a turbine of this kind three times without apparent diminution of vigour. Such turbines usually have from fifty to one hundred and twenty-five revolutions per minute.

Where the water is pure, as at Stormontfield, a minute dead fish or a fragment is readily perceived. The movements of the living fishes are also conspicuous. In Ireland, on the other hand, the tinted water (from peat-bogs) often considerably obscures observation, even white boards, placed at the bottom of a foot or two of water, giving little help in detecting small fishes which, further, appeared to shun them.

The net employed at Stormontfield had a central bag or pocket, with a smaller mesh than that used in Ireland; yet the Lochleven Trout (of the size of Smolts) went through the larger meshes at the edges ($\frac{1}{2}$ in. and $\frac{5}{8}$ in.), and were only detained by the sand eel-net placed across the stream beneath it, and which was a strong white net, having apertures about one-thirteenth of an inch. The paucity of the captures in some cases in Ireland was clearly due to the small Trout passing through the meshes of the net. While the active and uninjured thus might escape through the net, at the edges, or in some cases beneath it, the net retained dead fishes or fragments.

In performing such experiments the greatest care must be taken in handling the Trout, or in capturing them in the stream or in the turbine-pits with a ring-net, for injuries are thus often inflicted.

Breast Water Wheel.

So far as could be observed, the action of this wheel on Sea-Trout of $\frac{1}{2}$ lb. to 2 lb., and Trout (Lochleven) of the size of Smolts was nil. A dead fish came down at once, but the living remained in the tail-race.

Trout and Carp used in Experiments in Ireland:—

9-in. Rainbow Trout were hatched in				April,	1898.
Small	,,	(4$\frac{1}{2}$ in. to 6 in.)	,,	April,	1900.
,, *fontinalis*		,,	,,	March,	1900.
,, *levenensis*		,,	,,	February,	1900.
Common Trout		,,	,,		1900.
Carp, about 5 in.		,,	,,	June,	1899.

THE DEVELOPMENT OF THE SNIPE.

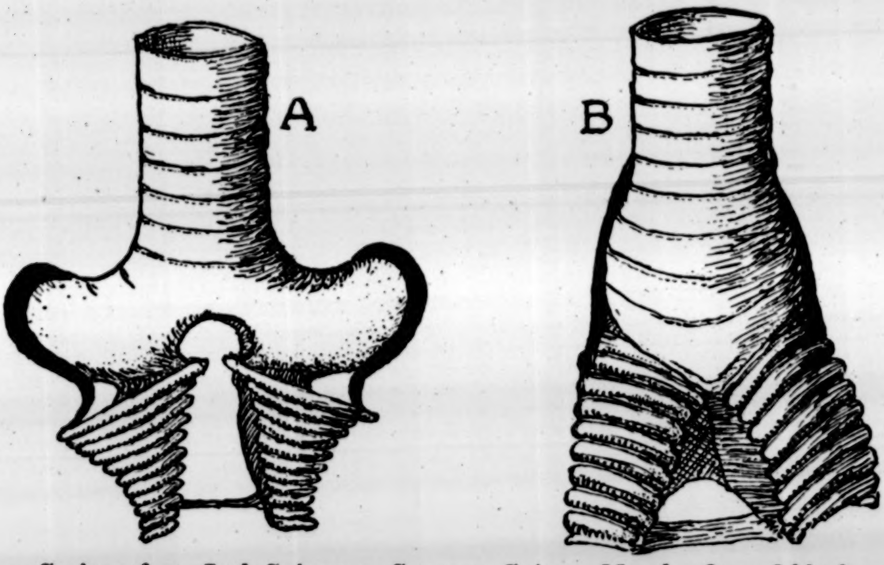
By F. J. Stubbs.

(Concluded from p. 212.)

It has been said by a high authority that the sternum, and especially its hinder portion, must not be used for taxonomical purposes, and it is a wise warning applied to those who seek to learn the affinities of great groups of birds. But it is a manifest error to ignore it in cases like the present one of these two Snipe. For instance, if we assume that the two species belong to the same genus, basing our opinions of their relationship on the fact that their plumages and outlines have much in common —in a word, that they are intimately related, and have progressed together since leaving the ancestral stem—what factors caused the tremendous changes in the internal and (for all we know to the contrary) useless elements of the hinder end of the sternum? If the birds are really related, and have kept their plumages alike throughout thousands of generations, the internal changes, carried out, too, without modifying the outward form, must provide one of the most remarkable problems in the whole field of zoology. The structural differences are not confined to the bones: I refer particularly to the sternum, which, in the Jack-Snipe, has *four* deep notches in the hinder margin, twice the number of those in the larger bird. There are other points of dissimilarity not so noticeable as those provided by the notches, but I do not propose to treat of them here. Yet I would draw attention to the syringes of the two birds, for they differ to a very high degree. This organ of the Common Snipe has been already figured by Wunderlich ('Nova Acta der Ksl. Leop.-Car. Ak. Nat.' Bd. xlviii. No. 1) and erroneously described by Gadow (Bronn's 'Thier-Reich,' and also Newton's 'Dictionary of Birds'), who gives it *two* pairs of intrinsic syringeal muscles —a particularly unfortunate error. Really, the bird has but a single pair, in this agreeing with all other waders. I believe

the syrinx of the Jack-Snipe has not yet been described or figured.

It is difficult to describe the syringes in the two birds, but as both are accessible the interested reader can readily examine them for himself when the occasion arises. Briefly, the syrinx of the Jack-Snipe is *twice as broad* as that of the Common Snipe, and is totally different in shape. In the former bird the *bronchidesmus* is narrow, in the other it is wide; the Common Snipe possesses a *semi-lunar membrane,* the other bird has none. I hasten to add that I do not believe the syrinx to be the organ of voice; the modern English opinion has no other basis than the mere assertion of one or two old anatomists, and there



Syrinx of—A, Jack Snipe; B, Common Snipe. Muscles figured black.

are several very serious objections to accepting this opinion.* I can recommend the dissection of the "vocal organs" of the Turnstone as a disquieting business to those who hold without question the views of Cuvier or Owen.

No one can deny that these two Snipe resemble one another very closely to all except expert eyes. I should think that few outside the ranks of sportsmen and professed ornithologists could state offhand the differences between the two birds, and I have a vivid recollection of the time when I could not always

* On this point a paper by J. M. W. Kitchen on the "Function of the Inferior Larynx" ('Auk,' ii. 24–31) might be consulted.

be certain, although handling the birds and seeing them in the fields. It is now easy to recollect that if the bird has any cross-barred feathers it is a Common Snipe, while if all are longitudinally streaked it is a Jack.

As a matter of fact, there must be hardly a bone or a single feather that is not different to the corresponding bone or feather in the other species. Even on the wing the two birds are not alike, for the rounded contours of the flying Jack-Snipe (reminiscent both of the Curlew and the Heron) separate it at once from its angular and impetuous neighbour. Strange to say, although the young at all ages differ vastly in the two species, the eggs are much alike, and it is said that some eggs of the Common Snipe are quite indistinguishable from those of the Jack-Snipe.

Although living side by side with the Jack for so many months in the year, the Common Snipe is not so well fitted to its habitat. The long bill, while enabling the owner to reach a greater depth of soil, is apparently useless for surface feeding when the ground is hard with frost, and, besides, the colours of the plumage are not so suitable. I have seen many Common Snipe on the ground, but, although far from easy to see, they are conspicuous compared with the smaller birds. For one thing, the colours are different; they are too warm. There is a lack of the purples, greens, and cool greys that match the light-reflecting mud, and enhance the brightness of the dorsal streaks. In the Common Snipe these streaks are not so distinct, and I have often noticed that the component feathers are not properly arranged, so that the stripes are broken, and unlike sedge or grass. In some individuals the cross-barred flanks are curiously successful in counteracting the effect of the remainder of the plumage, a fact that helps us to understand why the bird should substitute longitudinal markings for the bars. (If a Snipe is shot and falls on a green field or a bare fallow it may often be easily seen, and the observer may perhaps make the error of attaching too much importance to the fact. Yet a little thought will show that the colours are not intended to harmonize with short grass or bare soil, and are effective only in the environment for which they are designed.) It is a matter of common knowledge that the Common Snipe lacks the quiet

instinct of confidence in its colours that is so marked a feature of the Jack. Although, indeed, on occasion suffering an approach of a few feet, it more often rises at from twenty to a hundred yards, and usually advertises its going in no weak voice. It is a mistake to hold the opinion that the bird never rises in silence—it does so frequently.

The careful study of the growth of the individual Common Snipe and the examination of the adult plumage show at once that the bird is in a state of transition, *and that the livery worn by the Jack-Snipe is the end towards which it is progressing.* The young bird in its first plumage (after the down stage) is heavily cross-barred, but as it gets older the bars become less distinct, and arranged to form a *longitudinally* marked mosaic. Under the wings, where they will not show in the crouching bird, the transverse markings are well-defined, but on the exposed parts of the flanks, which must match the grass and sedge if the bird is to remain inconspicuous, one can trace the development from cross-bars to stripes. On the sides of the lower neck each feather is undeniably barred, yet the general effect is that of a streaked plumage (a state of affairs stated erroneously to be unknown in birds; *cf.* Newton's 'Dictionary of Birds,' p. 99). Really, this should be carefully observed in the dead bird, for it is difficult to describe except at considerable length.

The Common Snipe is notoriously instable in size, structure, colour, habits, and even geographical range. In a single batch of birds I have noticed bills varying in length from 2·30 in. to 2·80 in. It is hard to express bodily size in inches, and weight depends largely on the presence or the absence of fat, but the bird certainly varies in bulk. Normally, in England, the bird possesses fourteen tail-feathers, but occasionally odd ones are *detected* with twelve or sixteen. In North America the latter form is the usual one, and in Asia there is one form with tail-feathers varying from twenty to twenty-eight. This last is the "Pintailed Snipe" (*Gallinago stenura*) of ornithologists. I have had the opportunity of making careful dissections of some half dozen birds of this form, and comparing every part with the corresponding features of the Common Snipe. They are absolutely identical. The only differences are in the shape and

number of the feathers of the tail, and in the more heavily cross-barred plumage of the Asiatic bird.

It is worth noting that the American Snipe (*G. delicata*) is also *usually* more heavily barred than our own bird, and in this resembles the Asiatic form. Our own Snipe is found also in Asia, living side by side with the Pintailed Snipe, and in India Hume says that individuals with *sixteen* feathers are "common enough," and states also that "melanoid" varieties of the Pintailed Snipe occur. Presumably these belong to the variety so well known in England as "Sabine's Snipe." I have only examined the feathers, bill, and feet of the American form, and know nothing of its main structure; yet I do not hesitate to say that its anatomy will be in every way that of the Common Snipe.

I cannot think I am straying away from observed facts if I say that the above-mentioned forms of Snipe are nothing but varieties of a single species. For all I can learn to the contrary they differ only in the heaviness or otherwise of the transverse markings on the plumage, and in the number and shape of the feathers in the tail. Of course, I speak now from a biological standpoint, and not according to the views of those ornithologists who hold a difference in colour that is capable of being easily made by the careful use of methylated spirit sufficient grounds for forming a new "species." The characters adopted as "specific" in birds would be rejected with the utmost scorn by the botanist or the entomologist of to-day, and I am not sure that this is not true also for some "varieties" or "subspecies" that depend entirely upon faint differences in colour.

At any rate—to resume this particular discussion of the Snipes—we have first of all the Jack-Snipe, a remarkably stable bird, with no geographical races anywhere in its range; and, on the other hand, the Common Snipe, one of the most variable birds in the world, whether or not we include the so-called species *stenura* and *delicata*. In Great Britain the Common Snipe resembles the Jack-Snipe so closely that none except the expert is able to distinguish between them, and many ornithologists refuse to believe that they do not belong to the same genus.

Outwardly, so far as plumage is concerned, the two birds are alike; therefore, many students believe they are related. But

there are certain highly important features in which they do *not* agree. There is the syrinx; there is the skeleton, with the marked difference in the proportions of the ribs to the sacrum and the breastbone, and in the fact that while the hinder margin of the latter bone has *two* notches in the Common Snipe, it has *four* in the Jack. In the Jack-Snipe the tail has invariably ten feathers; in the Common Snipe the number, normally fourteen, varies from twelve to sixteen, and their shapes are entirely different. The two species show tremendous differences in *voice*, *breeding range*, *temperament*, *flight*, and *phylogenetic development*, and this dissimilarity extends in a lesser degree to the skull, bill, feet, food, and digestive organs.

Turning back to the main points of resemblance, we shall find that these are all special features fitting their owners to a particular habitat. Both live under much the same conditions, and for this life they require a special bill, foot, long inner secondaries, specially situated eye and ear, and a protective livery. It is perfectly clear that all these features would be acquired sooner or later by any bird living under similar conditions. They should not be used for purposes of classification.

We can take, now, for clearness sake, a single one of the details of internal structure in which the two birds differ, and I think the best feature will be the sternum. This bone is, genetically, built up from the ribs, and during development it throws out lateral and posterior processes which partly enclose the well-known "notches" so conspicuous on the hinder margin. Now, the Common Snipe has two of these notches, the Jack has four. They are absolutely structural characters, and are assuredly indications of the lines on which the sternum has developed.

For argument's sake we will assume that the two birds are really related, *and throughout their entire history have never been farther apart, systematically, than they are to-day*; and this is only another way of saying that they belong to the same genus. Yet, while remaining alike to all outward appearance, the internal skeleton has been undergoing tremendous changes. Without giving any external signs the Jack-Snipe has grown a second pair of *intermediate lateral processes*, enclosing an additional pair of notches. Why? I cannot imagine even a fantastic explanation.

I am unable to bring myself to accept this interpretation. It is clear to me that the two birds are *not* related except within the common relationship of the *Limicolæ*. The Jack-Snipe is a bird that has adapted itself (unconsciously, of course) to a life in marshes, just as the Ring-Plover has occupied the shingly sea-shore, and the Woodcock the forest. The fortunes of time have preserved its sheltering habitat, but destroyed its enemies, and it is therefore a secure bird. On the other hand, we get the Common Snipe, abundant, increasing, and variable to the verge of caprice.

I have shown that, although it has invaded the ancestral haunt of the Jack-Snipe, it is not yet quite fitted for its new place, but each *favourable* variation is used to establish the species, and in time, there is little reason to doubt, it will be as comfortable as its rival. This niche in the scheme of things is a desirable one, for it means security and food throughout the winter. So far this is largely a question of mere observation, but the theoretical aspect is rather interesting.

It will simplify matters if we assume that all marshes are alike, and assume, too, that the Jack-Snipe has reached its *optimum* of fitness for life in a marsh. It is rather difficult to imagine any vertebrate reaching the exact *optimum* of fitness, when not a cell can be changed or altered without a fall in suitability, but, for the sake of the theory, the reader must agree that this bird has done so. He will assume, too, that the Common Snipe is striving also towards the same goal, and then, logically, we must assume that *when it reaches the exact* optimum *of fitness* the two birds will be, *cell for cell*, alike, but unrelated.*

So much, then, for the theory. Such a state of affairs seems altogether impossible, but really our knowledge is not sufficient to state that it is impossible. Put in other words, it amounts to this: that *the place makes the organism* from whatever material happens to be on the spot. The marsh, in any country, makes the Snipe. The conditions that in America moulded the Humming Birds from a Coraciiform stock, in the Old World moulded the Sunbirds from the Passerine material most handy.

* Compare this with the interesting material gathered by Romanes in support of his theory of "Physiological Selection"—there are no records of hybrids between the Jack and Common Snipe!

One could go on for page after page giving such instances: Meadow-Lark and Kalkoentje; Auk and Penguin; the Common, Golden, and Marsupial Moles (an excellent instance—a century ago they would have gone assuredly into a single genus!); Swallows and Swifts; Gulls and (certain) Petrels; Diving Ducks and Divers, &c.

When two species closely resembling one another live side by side, the explanation of "mimicry" has been used. One might legitimately use it in relation to the present subject, and say with truth that the Common Snipe, although structurally not even nearly related, is mimicking the Jack-Snipe. In such cases naturalists have attempted to find some connection between the two parties to a case of "mimicry," yet it should be clear that, even though both are striving towards the same goal, and within a short distance of it, they may still not be in contact in any way.

I am afraid I have dragged the subject out too far, but really I have not said half that I would have said. The important question of food and feeding habits must be left for a separate paper, as must also be the subject of voice. I have accumulated many observations on other "pairs" of birds—Grey and Golden Plovers, Common and Dusky Redshanks, Common and Green Sandpipers—and hope to show that the relationships in these cases are merely superficial, and to show also how the patterns of the plumages have been directly changed under the influences of the habitat that each species has been forced, in the stress of competition, to occupy. One result of this study is that I always doubt the relationship between two organisms, either plants or animals, if they appear very closely allied and occupy the same country; yet the difficulties of investigating such sets as our three Leaf-Warblers (*Phylloscopus*), where one must work with, so to speak, a microscope in one hand and a field-glass in the other, are extremely discouraging, in spite of the high interest of the problems they present.

NEW ANNELIDS.

By the Rev. Hilderic Friend, F.L.S., &c.

The work of investigating the Annelids found in Great Britain, which I am aided in doing by a Government grant, is resulting in the addition of many new species to our lists. In the present paper I purpose alluding to two new species which have recently been received from Kew. In May a Wardian case arrived from Peru, which was found to contain some small worms. At first I discovered only two immature Perichætids, which I have so far not examined for actual identification. After keeping the soil in which they arrived for some weeks I found two specimens of a new Enchytræid, which I have named *Fridericia peruviana*. A full description of this species has been submitted to the Royal Microscopical Society, and it would therefore be out of place to repeat the details here.

A later examination of the earth has resulted in the discovery of a further addition, which I will now proceed to describe. The new worm is at once seen to possess three gizzards, and this points to the genus *Trigaster*, founded some years ago by Dr. Benham. It is not necessary that I should repeat his description in full. I therefore take the brief summary which Beddard gave in his invaluable 'Monograph of the Order Oligochæta,' published in 1895 :—

"Genus Trigaster, Benham.

"*Definition.* — Setæ strictly paired. Clitellum extensive, xiii–xl. Three gizzards in vii–ix; calciferous glands absent. Nephridia diffuse; a mucous gland present. Penial setæ absent.

"This genus only contains one species: *Trigaster lankesteri*, Benham (Q. J. M. S. xxvii. 94).

"*Definition.*—Clitellum xiii–xl; from segment xvii onward there is a ventral area free from glandular modification. Prostomium not imbedded in the buccal segment. Setæ strictly

paired. No dorsal pores. Intestine begins in xiii. Spermathecæ without any apparent diverticula.

"*Habitat.*—St. Thomas, West Indies."

In 1900, when 'Das Tierreich' was published, the species was split up into a type and two subspecies (*intermedia* and *calwoodi*), and four new species of *Trigaster* were recorded, but with only two gizzards in each case. So far as I am aware, there has been no true *Trigaster* (with three gizzards) added to the list, and if that is so the worm I have received from Kew is new to science.

1. *External characters.*—It would appear that the specimen upon which this description is based emerged from the cocoon in England, and it is therefore immature. It was of a light brown colour when living, and almost transparent when viewed in water under the microscope. Length 15 mm., breadth 1 mm., number of segments 50. The prostomium is small and delicate, and was seen when alive to be drawn in to and everted from the buccal aperture. Setæ arranged as in *Lumbricus*, i. e. four pairs on each segment, but not equal in size and length in the dorsal and ventral bundles. When the worm moved, it reminded one rather of a planarian than of an oligochæt, and it had more flexibility than our British earthworms.

2. *Internal characters.*—Owing to the small size of the animal and its delicate structure it was possible to examine it as one might examine a Tubifex or Enchytræid under the microscope. The worm was rich in blood, the dorsal vessel large, and covered with chloragogen cells, which in front of the intestine formed a dark mass. In advance of the gizzards the blood-vessels form a rich plexus or network which enabled the red blood to suffuse the whole of the organs. Pulsating hearts between the gizzards and the intestine made that portion a bright red, in striking contrast with the dark chloragogen cells which were here amassed. The gizzards lay in segments 9, 10, 11, and the foremost one was of quite a different texture from the other two, being composed of fibres which crossed each other so as to give the appearance of woof and warp. The principal hearts lay in segments 12–15, and the intestine commenced in 19. A very striking peculiarity of the intestine was observable in the fact that the hinder portion, from about the 33rd to the 50th segment, was only half as large as the foremost portion.

The main points of difference from Benham's type are to be found in the much diminished size, the position of the gizzards and hearts, and the segment which marks the commencement of the intestine. If we place these points side by side their value will at once be seen. In column I. I give details of the subspecies of *T. lankesteri*, in column II. those of the type, and in column III. the particulars relating to the new species :—

Details.	I.	II.	III.
Length	240–280 mm.	?	15 mm.
Segments	580	?	50
Diameter.........	4–6 mm.	?	1 mm.
Gizzards	5, 6, 7	7, 8, 9	9, 10, 11
Hearts............	Last in 13	?	Principal in 12, 13, 14
Intestine begins	?	13	19

If we turn to the allied genus *Benhamia*, we find that the species range from 16 mm. in length in *B. curta* to 540 mm. in *B. rosea*, so that we are prepared to find a similar divergence in *Trigaster*. I should assume that the new species may grow to double the present dimensions when adult, but the very limited number of segments shows that it is comparatively a pigmy form. Unfortunately, the very juvenile condition of the specimen renders it impossible to say anything about the sexual organs, but in every other respect our information is definite and conclusive.

On account of the small size and the paucity of segments I propose for this new annelid the name *Trigaster minima*.

NOTES AND QUERIES.

MAMMALIA.

The Lesser Shrew (Sorex minutus) in Yorskhire.—This smallest of British mammals is no doubt much commoner and more generally distributed than is often supposed, it being easily overlooked unless systematically trapped for, and published records not being very numerous. I have for many years been familiar with it in Northumberland and on the Scottish Border, and have likewise met with it in Merionethshire, Devon, and Cornwall, and having during the last two years taken upwards of a dozen specimens in the immediate neighbourhood of Ilkley-in-Wharfedale (where it had hitherto been looked upon as not at all common, though a single example had already been taken near Bolton Abbey, and one or two have since been reported from neighbouring localities), perhaps the fact may be worth putting on record. My first specimen was rescued from a cat, on the edge of Ilkley Cemetery, during a hard frost with the ground covered with snow, in January, 1909, since which date others have been trapped on both banks of the Wharfe, as at Middleton, Bow Gill, and on the slope of the moor between the town and the well-known Cow and Calf rocks. And, as at least one example has been taken in almost every spot in which traps have been set, it is obvious that the species is not uncommon here. Specimens have been presented to Ilkley, Bradford, and Keighley Museums. — George Bolam.

AVES.

Nidification of the Whitethroat (Sylvia cinerea).—The Common Whitethroat is generally a rare bird about Hebden Bridge; it is outnumbered both by the Blackcap and the Garden-Warbler. This year it has returned in even less numbers than usual, but on June 9th I watched a male in vigorous song, but did not see a female. The following day the bird was singing in the same tree, and J. Fenton Greenwood and myself searched closely for a nest, but were unsuccessful. On the 11th the bird was still singing lustily, and Mr. Greenwood saw it descend to a blackberry-bush. Examining this later he found a completed but empty nest, undoubtedly belonging to this species. The nest was kept under observation, but

no eggs have been deposited, and, though the male continued to sing in the vicinity for more than a week after, no traces of a female have ever been seen. It may be assumed, therefore, that the nest was constructed entirely by the male bird, which for some reason, most probably because of a scarcity of females, never paired. The case may be exceptional, and merely due to circumstance, or it may illustrate the general custom. Naturally, where males and females are equally represented, it would require a great amount of observation to definitely decide whether one sex only in this or any other species is concerned with nest building.—WALTER GREAVES (Hebden Bridge, Yorks).

The Grasshopper-Warbler (Locustella nævia).—While sailing on the Norfolk Broads a few days ago we perforce became quite familiar with the song of the Grasshopper-Warbler. One of these shy little birds was singing near the river not far from Wroxham, when I sallied forth with a candle-lantern one evening about 11 p.m. It was quite dark, and my intention was to catch a glimpse of this Warbler, so elusive when approached in the sunny hours. When within a yard of my quest, to judge by the sound, I passed the lantern under and around a solitary bush from which the song appeared to originate, but my action, however, failed to reveal the form of the songster. I then gently pulled aside a projecting twig, and was startled, not to say chagrined, by the flutter of a soft wing against my hand, but it was not long before the stridulous notes began again on the other side of the bush. This time, after creeping carefully round and peering with the lantern into a gap in the foliage, I was rewarded by a perfect view of the Warbler perched on a branch not more than two feet in front of me, and pouring forth its lonely torrent of song. As it sang the bird's throat quivered continuously, but the rest of its body was absolutely motionless. In a moment, however, a movement of mine caused it to turn about, and I was able to make a detailed observation from the side. In the act of singing the head is tilted upwards, while the tail is slightly depressed, perhaps by way of compensation. The legs are fully bent forwards, lying in close contact with the body wall. The singing position is thus rather a crouching than a craning attitude. The twig selected for a stance was situated towards the centre of the bush, and not easily visible from outside. At first, while watching, I held the lantern just to one side of my head, and possibly the light may have partially dazzled the bird, and thus covered my movements. In this connection it was most interesting to find that,

whether the light was withdrawn to a distance or concealed or waved slowly across the bird's field of vision, the singing continued as before without a pause. I found also that the noise caused by a savage kick amongst the undergrowth at the bottom of the bush was immediately followed by a cessation of singing, but only for a moment, and six kicks in succession at intervals of a few seconds were promptly sandwiched with five snatches of song. On the other hand, a stealthy or gradual movement was followed by a much longer silence which remained unbroken for a minute, or even longer. Finally, before leaving, I pushed the lantern slowly into the bush and followed it up with my face, which I succeeded in placing within nine inches of the songster before the slightest exception was taken to my presence.—A. P. SAINT (Nottingham Terrace, Marylebone Road).

Yellow Wagtail (Motacilla raii).—In Mr. O. V. Aplin's notes on decrease of Corn-Crake, &c. (*ante*, p. 237), mention is made that "Ray's Wagtail is decreasing in numbers compared to some years ago. The usefulness of protection for this or any bird is doubted." I would like to state that in Upper Airedale and Wharfedale, where we are great believers in protection, the Ray's is now our commonest Wagtail. In one small triangular, three-acred field alongside the Wharfe there were three nests each with six eggs; similarly in Airedale, it seems to be yearly increasing as a breeding species. Last year (1910) it was particularly abundant in Upper Airedale. Thirty years ago it was comparatively scarce. Perhaps this species is extending its breeding range further north, and this, with the protection afforded, accounts for its thriving in the districts mentioned.—W. H. PARKIN (Studholme, Shipley).

Alpine Swift in the New Forest.—I recently saw an Alpine Swift (*Cypselus melba*) at Brockenhurst, and the appearance of this rare visitor to our country is perhaps sufficiently interesting to be recorded in 'The Zoologist.' It was on the morning of Sunday, May 28th, that my friend Mr. E. A. Waterhouse and I saw the bird flying at no great height close to Brockenhurst Bridge. In fact, it was flying only sufficiently high to clear the thorn-trees and high bushes by the river, the course of which it appeared to be following from west to east. As the bird was coming towards us in bright sunshine, we were able to see it distinctly, and its white breast was conspicuous, so that we had no doubt of the species. Indeed, it was so obviously a large Swift that it was impossible to mistake it for any other bird. —R. S. MITFORD (35, Redcliffe Square, South Kensington).

Marsh-Harrier in Kent. — On June 22nd I observed a Marsh-Harrier (*Circus æruginosus*) in Thanet. The bird was battling vainly against the stiff south-west wind that was blowing at the time. It finally settled in an open field, where I managed to get a very fair view of it, though it would not allow me to approach nearer than eighty or one hundred yards. — COLLINGWOOD INGRAM (Sussex Mansions, Westgate-on-Sea).

A Pelican Fifty-two Years of Age.—A White Pelican (*Pelecanus onocrotalus*) forty-one years of age, and then still living in the Zoological Gardens at Rotterdam, is recorded in 'The Ibis' for 1899 (pp. 32, 38), on the authority of Dr. J. Büttikofer, Director of the Gardens, and well known as a zoologist. Assuredly there are not a great many instances of birds passing the age of fifty years which are capable of verification, but this is one. The bird died, as I now learn from Dr. Büttikofer, in November, 1907. As it had been received from the Zoological Gardens at Amsterdam in May, 1857, and entered as being then an adult bird, it could not have been less than fifty-one and a half years old, and probably was more. It was marked by an easily recognizable incision in the membrane of one of its feet, and Dr. Büttikofer considers any mistake of identity to be out of the question.—J. H. GURNEY (Keswick, Norwich).

EDITORIAL GLEANINGS.

A 'STANDARD OF EMPIRE' cable, dated Cape Town, March 15th, says:—"A sensation has been caused in Cape Town by a thrilling encounter between a large Octopus and a number of men at the docks. A native was standing on a step close to the water, when he was suddenly seized by the Octopus. Three other natives were also clutched by the long tentacles of the great creature, which strove to drag them into the water, where they would have been completely at its mercy. Help fortunately arrived in time to prevent that contingency, and the Octopus was drawn out of the water. It retained its grasp on the men, however, despite the endeavours that were made to chop off its tentacles with spades. Only after a long conflict was the Octopus finally despatched. The adventure is without precedent in the annals of Cape Town."

YOUNG EELS TWO HUNDRED MILES INLAND.—Mr. R. B. Marston, writing in the 'Fishing Gazette' of June 3rd last, says:—"Mr. W. G. Ashford, of Messrs. Milward's, of Redditch, was telling me recently of the fine Eels they get in their Barnt Green Fishing Club's water, of which he is Hon. Sec. He said they saw the small Eels come up and the large ones go down. I asked him if he could get me specimens, and he kindly sent me a fine Eel of nearly three pounds, which was excellent eating; also, on May 24th, he sent me in a bottle with some damp moss some small live Eels, 6 in., 7 in., and 8 in. in length. I gave them to Mr. Green, the naturalist, at the east end of Covent Garden Market. Mr. Ashford says:—'These young Eels were caught above a little waterfall a mile from the source of the Arrow, in Worcestershire. The Arrow is a tributary of the Avon, which again is a tributary of the Severn. The distance from the sea, as the crow flies, is about one hundred and twenty miles, but the distance they must have travelled can certainly be taken as two hundred miles. Of course, the distance they travelled in *salt* water is vastly more than that.'"

AT a meeting of the Zoological Society of London, held on June 27th last, Dr. W. T. Calman, F.Z.S., exhibited a number of living specimens of the Brine Shrimp (*Artemia salina*) which had been bred from Tidman's Sea Salt. He remarked that this sea salt, as sold in the shops, was found frequently to contain living eggs of *Artemia*, and that it was easy to obtain a supply of living specimens. An eight per cent. solution, allowed to stand for a few days, produced a swarm of larvæ, and these could be fed on the strained juice of green leaves and raised to maturity.